RCNP EXPERIMENT E

PROPOSAL FOR EXPERIMENT AT RCNP

4 August 2017

TITLE:
Title title

SPOKESPERSON:

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Title or Position	Postdoctoral Researcher
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EXPERIMENTAL GROUP:

Full Name	Institution	Title or Position
Masahiko Iwasaki	RIKEN Nishina Center for Accelerator-Based Science	Chief Scientist
Katsuhiko Ishida	RIKEN Nishina Center for Accelerator-Based Science	Vice Chief Scientist
Akira Sato	RCNP	Assistant Professor
Dai Tomono	RCNP	Assistant Professor
Koichiro Shimomura	KEK/RCNP	Associate Professor

RUNNING TIME:

Installation time without beam	2 days(for each beam time)
Development of device	1 day
Test running time for experiment	1 day
Data runs	3 days

BEAM LINE: Ring : WSS course

BEAM REQUIREMENTS:

Type of particle	Proton
Beam energy	392 MeV
Beam intensity	≤ 1 μA
Other requirements	None

BUDGET: Experimental expenses 500,000 yen

SAFETY CONTROLLED ITEMS:

- Hydrogen gas

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TITLE:
Measurement of the lifetime of hyperfine excited state in muonic hydrogen atom

SPOKESPERSON: Sohtaro Kanda

SUMMARY OF THE PROPOSAL

This proposed experiment is the first measurement of the lifetime of hyperfine excited state in muonic hydrogen atom. The experiment is one of the essential steps towards a new precision measurement of the proton radius via a laser spectroscopy of the muonic hydrogen ground-state hyperfine splitting (HFS). Even the proton radius is one of the most fundamental observables in sub-atomic physics, there is a significant inconsistency between the independent experimental results. This unsolved problem is so called "proton radius puzzle".

The muonic hydrogen HFS is the most suitable observable to extract the proton Zemach radius which is defined as a convolution of the charge distribution with the magnetic moment distribution. One of the obstacles to perform a spectroscopy of muonic hydrogen is the short lifetime of the HFS triplet state which is excited by a laser light. The de-excitation is induced by a three-body inelastic scattering $\mu p(F=1)+p \rightarrow \mu p(F=0)+p$ where F is the total angular momentum of a muonic hydrogen. On the lifetime of the HFS triplet state in muonic hydrogen, only theoretical predictions are known and no measurement had been performed because of experimental difficulties. The proposed experiment aims to measure the lifetime with the relative uncertainty of 5 % as a function of the hydrogen gas density.

The proposed experiment is a muon spin rotation measurement with a low density hydrogen gas target. The Larmor frequencies of the muon spin in a muonic atom depend on its HFS state and nuclear spin. Therefore, the lifetime of the HFS triplet state can be extracted from an asymmetric muon-decay-electron time spectrum. The proposed experiment is a pioneering experiment as a muon spin spectroscopy with a negative muon and a low density gas target. This is not only a preliminary experiment for a muonic hydrogen spectroscopy but also an independent study which provides a systematic understanding of a fundamental spin-dependent three-body interaction in a muonic system.